Abstract

Similar to the general population, female athletes often adopt dieting behaviors in order to attain their image of the ideal body. With the premise that restrictive eating is reflective of investment in one's appearance, many believe decreasing energy intake or increasing physical activity will help promote weight loss and lead to achievement of the ideal body. However, the metabolic influence of restrictive eating may actually work against attaining a better body composition by decreasing metabolic rate and encouraging fat storage. This study was designed to evaluate the relationship of body image with body fatness and metabolic rate in Division I intercollegiate female athletes. Female athletes from both lean and non-lean sports participated in the study; lean sports represented included synchronized swimming, swimming and crew while non-lean sports included athletes from ice hockey and soccer. Body image was evaluated using the Multi-dimensional body-self relations questionnaire (MBSRQ), Eating Disorder Examination Questionnaire (EDE-Q), Tendency to Diet Scale, and comparison of Silhouette differentials. Body fatness was estimated using the BodPod while resting metabolic rate (RMR) was estimated using a ReeVue indirect calorimeter. The questionnaire and body composition results indicated that there were no significant differences between lean and non-lean sport groups, or between individual sports. A number of significant correlations were established between body image subscales to RMR and body fatness values.

Body Fatness, Body Image, and Resting Metabolic Rate in Lean and Non-Lean Collegiate Female Athletes

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By
Alexandra M. Schueler

The Ohio State University

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Project Advisers: Dr. Jackie L. Buell, Director of Sports Nutrition

Dr. Nancy A. Rudd, Associate Professor, Consumer Sciences

Introduction

Athletes, paralleling the general population, often alter their diets in order to achieve an ideal body type. Many athletes practice dieting behaviors under the premise that restrictive eating behavior reflects dedication to one's appearance and sport. Continued dieting behaviors, however, are thought to lower an individuals' energy needs (resting metabolic rate) and promote fat storage. Deutz et al have published a study of female athletes that demonstrates some female athletes who restrict calories throughout the day have increased body fatness (Deutz, Benardot, Martin & Cody 2000). This current study will continue to examine the relationship between body fatness and resting metabolic rate to body image in both lean and non-lean intercollegiate female athletes. A lean sport is a sport in which a lean figure is desired for performance, weight class, or aesthetic purposes, for example swimming, synchronized swimming and crew. A sport is considered to be non-lean if a lean body figure is not considered to be required for an athletes' athletic performance or appearance; non-lean sports used in this study include ice hockey and soccer.

The preliminary study examined early data from 17 female athletes from The Ohio State University and found no difference between dieting behaviors, resting metabolic rate and body fatness between lean and non-lean athletes (Watson 2009). The present study will look further into the relationship between body image and resting metabolic rate along with body fatness by examining different facets of body image with the larger number of subjects. The variety of body image questionnaires used in this study reflects the complex nature of body image evaluation and the numerous factors that may play a role in self-perception. The compendium of questionnaires for this study included the Multidimensional Body Self-Relations Questionnaire, Eating Disorder Examination Questionnaire-6, Tendency to Diet Scale and Silhouette drawing differences. The multi-dimensional analysis of body image to resting metabolism has led this study to examine four research questions:

1) Do the Appearance Orientation and Appearance Evaluation domains of the Multidimensional Body Self-Relations Questionnaire correlate with a decreased resting metabolic rate or body fatness, and is there a significant difference in Appearance orientation or evaluation for the lean and non-athlete female athlete groups, or by sport?
2) Do the subscales of the Eating Disorder Examination (concern for Weight, Shape, Eating, and Restraint) correlate with a decreased resting metabolic rate or body fatness, and is there a significant difference between lean and non-lean female athlete groups, or by sport?
3) Does Tendency to Diet score correlate with a decreased resting metabolic rate or body fatness, and is there a significant difference in the tendency to diet score for the lean and non-athlete female athlete groups, or by sport?
4) Do the differences between perceived and ideal Silhouette drawings, suggestive of the body satisfaction of an individual, correlate with a decreased resting metabolic rate or body fatness, and is there a significant difference between lean and non-lean female athlete groups, or by sport?

Literature Review

Many factors play into one's perception of self, including self-esteem, cultural norms, and perhaps most notably, participation in sport and body image. Body image is a multi-dimensional and complex concept that encompasses not only a person's physical body but also thoughts, emotions, beliefs and actions (Cash 2008). Once thought of as a straightforward subject matter, body image has become a magnified area of study in athletes and non-athletes alike. Studies have demonstrated that body image is widely variable across populations and is influenced by age, gender and ethnicity. Additionally, level of body image concern and self-evaluation vary with each individual's thoughts and experiences (Hubley and Rusticus 2006). University athletes are subjected to the pressures of many cultures simultaneously, including the experience of being a female student, heritage group, and sport experience as influenced by coaches, parents, teammates and other sport personnel.

Due to the desire to better understand body image, questionnaires and scales have become popular research tools to help identify or objectify specific disordered eating or exercise behaviors. In 1997, a survey taken by over 4,000 individuals revealed that 89% of women wanted to lose weight and 56% of women were dissatisfied with their appearance (Garner 1997). Similar results were found in a study of college-aged women where 83%, regardless of weight status, stated they used dieting for weight loss (Malinauskas 2006). Garner also showed that up to 60% of body image was determined based on weight. In 2008, a national survey of middle-aged women revealed 80% desired to lose weight, and over 50% of these same women were of "normal" weight (BMI < 25) (McLaren and Kuh 2004). These dissatisfaction estimates are alarmingly high when one considers that the concept of body image is based on multiple factors that include not only physical factors but psychological factors as well. Other findings show that the desire to lose weight is not just an issue in adult populations, but is also found in adolescent populations (Polivy & Herman, 2007). In general, the prevalence of eating disorders in adolescents ranging from middle school through young adulthood is estimated to be a high percentage; and children who display disordered behaviors at a young age are at a greater risk of continuing this behavior throughout their lifetime (Neumark 2011). The increasing prevalence of disordered eating behaviors has lead researchers to further examine body image patterns amongst populations.

Athletes often face pressures to not only perform well in their sport, but also to obtain an ideal body for their sport. This poses a separate and additional set of pressures different from the “look good” pressure in the general population. Females have been shown to be more preoccupied with their appearance than males (Rodin 1984), and athletes may be at a greater risk of developing disordered eating than non-athletes. Pritchard et al studied 1,501 athletes and non-athletes, and found 13% of non-athletes displayed disordered eating compared to 36% of athletes (Pritchard, Milligan, Elgin, Rush and Shea, 2007). Similar to the general population, disordered eating may lead female athletes to practice restrictive eating habits and increased energy expenditure in order to lose weight, specifically targeting body fat.

The female athlete triad is a specific example of suppressed energy intake and/or increased energy expenditure (Nattiv 2007). The female athlete triad consists of three categories: disordered eating, osteoporosis, and amenorrhea (Beals 1999). Although previously thought to occur dominantly in lean sport athletes, like runners, evidence supports there is only a significant difference seen in menstrual dysfunction amongst lean and non-lean athletes (Beals 2006). In addition, Rudd and Carter have shown that 18.8% of lean athletes displayed disordered eating habits (as estimated using the Questionnaire for Eating Disorder Diagnoses) while only 12% of non-lean athletes had similar scores (Rudd and Carter 2006). Moreover, lean athletes displayed disordered eating at a higher frequency than non-lean athletes or the general population. This could be attributed to the differences in sport classifications and the stresses of lean athletes and the differing stresses placed upon non-lean athletes.

This current study defined lean sports as sports as where a lean figure was beneficial athletes for performance or aesthetic purposes, and this study included swimming, synchronized swimming and crew. Lean female athletes, like runners, have been identified to have a higher risk for disordered eating (Reinking 2005) so the interest of this study is to determine if lean athletes hold differences in body image or dieting behaviors. Non-lean sports, for comparison, were defined as sports where a lean body figure is not considered primary to the athlete in either performance or appearance categories, and this study included the sports soccer and ice hockey.

The concept of body image is a complex and multi-dimensional phenomenon that is highly influenced by individual experiences, beliefs, and the ever-changing societal attitudes about the ideal female body (Bonafini 2011); this causes individuals to respond within their own perceptions. It has been shown that subjects with disordered eating significantly overestimated their weight relative to a control model and exhibited more body dissatisfaction (Shafran and Fairburn 2002). Rudd and Lennon reveal that risky appearance-management behaviors are often practiced in response to social and cultural pressures; this supports that a person's thoughts and feeling about her own body is under personal control and able to be freely altered (Rudd & Lennon 2000).

The tools used in this study to objectify body image included the Multidimensional Body-Self Related Questionnaire (MBSRQ) (2 subscales), Eating Disorder Examination

Questionnaire (EDE-Q) (4 subscales), Tendency to Diet Scale (TD) and Silhouette Drawings (Sil). The MBSRQ is a self-administered questionnaire that has proven to be a reliable indicator of body image in both males and females; concordance values of 0.995 and 0.997 in Appearance Evaluation and Appearance Orientation sub scales, respectively, were seen in a sample of 2,052 females and males (Brown, Cash, & Mikulka 1990). The domains of the MBSRQ are appearance orientation and evaluation, fitness evaluation and orientation, and health/illness orientation and evaluation and are determined based on a continuous scale of numerical scores for each question, ranging from 1 (Definitely Disagree) to 5 (Definitely Agree); other sub scales are concerned with weight label, weight restraint, and body area satisfaction. Accordingly, persons who value factors or events of a given subscale, such as Appearance Orientation, are more likely to engage in activities to maintain or enhance this set of characteristics, thus score higher on the subscale. This confirms both the behavioral and cognitive evaluation of the MBSRQ (Brown, Cash, & Mikulka, 1990).

In the current study, the Appearance Orientation (AO) and Appearance Evaluation (AE) subscales of the MBSRQ appearance domain were queried and examined. The AO subscale is used to determine the level of importance one places on their appearance by taking into account what practices or activities participants display in order to maintain or alter his/her appearance (Brown, Cash, & Mikulka, 1990). After scoring the AO subscale according to published instructions, a high AO score indicates that a person places high importance on their appearance while a low AO score indicates that a person does not consider their appearance to be an important reflection of themselves. The AE subscale indicates how the subject evaluates personal appearance, or how pleased or satisfied she is with her body, and what practices she adopts to alter or maintain body satisfaction or dissatisfaction (Brown, Cash, Mikulka, 1990). A higher

AE score indicates a subject is pleased with body appearance and lower scores indicate more body dissatisfaction. The AO and AE subscales of the MBSRQ provide objective markers of orientation and evaluation of appearance.

The EDE-Q has also proven to be a reliable indicator of behavioral features and eating disorder psychology with Cronbach's alpha values (a measure of internal reliability) of 0.75, 0.78, 0.67, 0.79, in restraint, eating, weight, and shape concern, respectively, indicating a satisfactory degree of internal consistency (Cooper, Cooper and Fairburn 1989). The EDE-Q has also been shown to be valid regardless of delivery method, such as interviewing or self-report questionnaire, when there are no problems of definition (Fairburn and Beglin, 1993). It is interesting to note that although the EDE-Q is an accurate predictor of women's attitudes regarding eating behaviors and body evaluation, it should be used to compare women of the same regional geography (Mond, Hay, Rodgers, & Owens, 2004) as the norms and cultural ideals of beauty and an appealing body shape may differ between geographical cultures. The EDE-Q has a variety of responses that include an estimation of the number of days a participant displayed a dieting behavior in the previous 28 days, and numerical responses ranging from 0 (Not at all) to 6 (Markedly). A higher EDE-subscale score indicates that a subject places a greater focus or concern on shape (EDE-S), weight (EDE-W), eating (EDE-E), or restraint (EDE-R) and is at a higher risk for practicing restrictive eating behaviors. The EDE objectifies these four perspectives of body image.

The Tendency to Diet Scale (TD) was created and validated in the RENO Heart Study (Kayman and Brunner, 1997) and marks a person's dieting behaviors and attitudes about the need to diet. In this study, TD was scored according to prior guidelines (Kayman and Brunner, 1997), and evaluated based on the sum of the numerical responses provided by participants, where a higher score indicates a higher tendency to diet. The internal reliability of this scale has been shown to be 0.79, indicating the TD is a reliable tool to use clinically (Kayman and Brunner, 1997). This scale has not been validated in athletes, but has been shown to directly correlate with body weight where overweight individuals score higher, and women have higher TD scores than men (Kayman and Brunner, 1997). Therefore, TD likely contributes to the description of the dieting profile and is a unique questionnaire to include in this study on athletes.

The differences in Silhouette drawings have been widely used amongst researchers and clinicians to evaluate body satisfaction and body image, and continue to be a valuable and valid tool (Stunkard 2000). Silhouette tests are easy to administer and require little time to be completed by the subject, making them an often utilized screening tool. Subjects are asked to choose their “real” body silhouette and “ideal” silhouette from the illustration of sample silhouette models; the silhouettes represent a continuous scale of Body Mass Index (BMI) scores (Peterson, Ellenberg & Crossan, 2003). Any deviation of the participant’s ideal body silhouette from their real body silhouette indicates body dissatisfaction; as the real and ideal body silhouettes become more disparate (higher number), body distortion grows as well, demonstrating a correlation between body dissatisfaction and body distortion (Garner 1997). The present study utilized the Contour Drawing Rating Scale version of silhouettes as shown in Figure 1. This updated model added clearly defined facial features, such as eyes and mouth, which were lacking in previous silhouette models (Thompson and Gray, 1995). The newer model was developed to display “finer degrees of difference between proximal figures together with consistent differences in size between successive figures” (Thompson and Gray 1995). Significant differences have also been noted between genders, where women were more often displeased with their perceived real silhouette figure and desired a smaller silhouette. This perceived difference between one's real body and ideal body or silhouette differential can be a contributing motivation to practice an imbalanced restrictive dieting or over-exercising pattern (Keeton 1990).

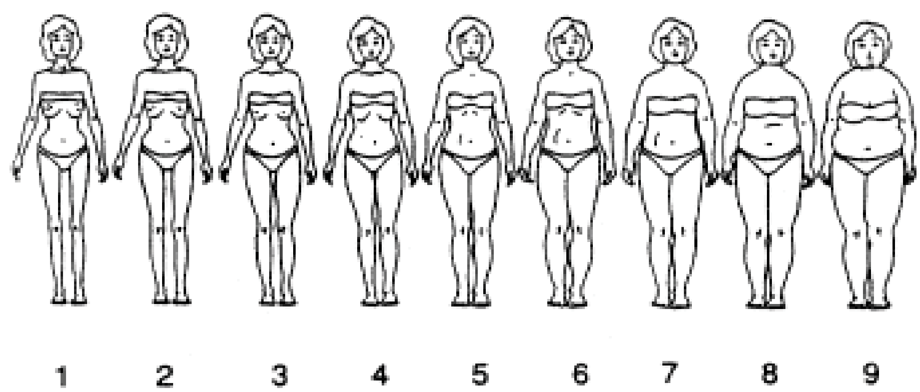

Figure 1. Contour Drawing Rating Scale (Thompson and Gray, 1995)

The final aims of this study were to evaluate relationships between resting metabolic rate (RMR) and body fatness to body image (and body image subscales) in female athletes. Resting metabolic rate is defined as the energy expended in a resting state following an overnight fast and is the energy needed to maintain body processes. Many factors have been found to influence RMR including age, gender, ethnicity, and body composition (Ravussin 1989 & Ferraro 1992). There is a strong, direct relationship between fat free mass (FFM) and RMR because FFM (which includes muscles, bone, and organ masses) is more metabolically active, therefore requiring more energy to maintain (Ravussin et al 1986). This may explain the depressed RMR values seen in athletes with increased body fatness discussed previously from the Deutz study (Deutz et al 2000).

There has been some discrepancy over whether chronic or acute changes in physical activity affect RMR independent of FFM. One study indicated male endurance athletes had a higher RMR than males of a sedentary nature independent of body composition (Poehlman 1989, 1990), while other studies argue there is no difference between of RMRs of endurance athletes and sedentary individuals (Broeder et al 1992; Lundholm et al 1986). This topic is still under heavy debate. Acute bouts of exercise, on the other hand, have been shown to increase RMR in the time immediately following exercise in trained endurance athletes (Binzen et al 2001). The greatest increase in RMR can be seen immediately following exercise and progressively decreases as time increases post-workout. Binzen provides evidence indicating that 2 hours after an exercise session, excess post-exercise oxygen consumption (EPOC) was still slightly elevated. Post-exercise RMR changes may also be attributed to increased body temperature (Gaesser & Brooks1984) and increases in triacylglycerol cycling (Bahr, Hansson & Sejersted 1990). These changes in RMR after bouts of short or long-term exercise may be a contributing factor to differences of RMR of athletes in this study, depending on their degree of training and whether or not they were in-season.

Other research discusses the effect dieting has on RMR in various populations. Severe energy restriction versus moderate energy restriction was seen to lower RMR to a greater extent in obese women over a six month period (Sweeney, Hill, Heller, Baney & DiGirolamo 1993). There is some debate as to whether the duration of the dieting period affects the degree to which RMR is lowered because other studies have shown that some chronic female dieters do not exhibit a lower RMR, while others have a decreased RMR (Gingras et al 2000; Wadden et al 1992). Contrary to the widely held belief that weight cycling and periods of dieting restriction will suppress the metabolic rate, Wadden et al were unable to identify a difference in RMR between high cycling (7.1 +/- 0.7 diets and lifetime weight loss of 8.3 +/- 11 kg) and low cycling (2.8 +/- 0.4 diets and lifetime weight loss of 26.4 +/- 3 kg) groups of obese women (Wadden et al 1992). When closely evaluating the group means, it is noticeable that the low cycle group lost a lot of weight while those who dieted more often did not lose as much weight. The number of cycles and more extreme weight loss may both lead to depressed metabolism thus the indifferent result. Other factors may contribute to metabolism differences such as lean body mass and degree of dietary restraint (calorie level). Genetic factors are a strong determinant of RMR, depending on the internal work required to maintain an individual's body processes. The heritability of factors that contribute to RMR determination has been shown previously and also the extent to which these factors are mutable (Bouchard, Tremblay, & Nadeau 1989). Finally, regardless of subject population, differences have been documented in RMR values when measurements were taken in the morning compared to afternoon, where afternoon values were consistently ~100 kilocalories (kcal) greater than morning measurements (Haugen et al 2006). Many factors contribute to an individual's RMR measurement where effects of different factors vary from individual to individual, making it difficult to isolate specific reasons for differences in RMR. The wide variability of RMR across a population will also influence the statistical indifferences when a low number of subjects are studied.

In the current study, RMR was measured using a ReeVue indirect calorimeter. Indirect calorimeters have several advantages over traditional metabolic measuring devices in that they are smaller and require less frequent calibration (Korr Company White Paper accessed 2012). The DeltaTrac indirect calorimeter is a respected and highly validated established clinical standard (Phang 1990; Weissman 1990), and the ReeVue has been validated against the DeltaTrac System where the ReeVue demonstrated an r^2 value of 0.985 of the corresponding

DeltaTrac values (Korr Company White Paper accessed 2012). The differences in calculated RMR values have been shown to be slightly elevated when determined using the ReeVue when compared to the DeltaTrac System with an estimated coefficient of variance of 11.9% (Cooper et al 2009). The ReeVue is a self-calibrating machine, and is able to determine RMR without a carbon dioxide estimate. The ReeVue indirect calorimeter is a reliable indicator of RMR in subjects and is practical for use in the laboratory (Korr Company White Paper 2012).

Body composition (fat mass and fat free mass) is conveniently measured using a BodPod machine. The BodPod is a non-invasive method that estimates body composition using air displacement plethysmography (changes in volume) to estimate body density. The BodPod has been shown to be easy to operate, quick in procedure, and more accommodating than the gold standard of body composition determination of hydrostatic (underwater) weighing (Vescovi, Zimmerman, Wayne, Hildebrandt, Hammer & Fernhall 2001). There is some discussion concerning the accuracy of the BodPod in different population groups including individuals outside of the accepted average range for body fatness: men 15.4%–22.0%, women 18.4%–28.5% (Vescovi et al 2001). The BodPod has, however, been shown to be a valid indicator of body composition in female athletes. Bentzur et al 2008 examined 30 Division 1 Track and Field female athletes for body composition, and the BodPod was determined to be statistically similar to hydrostatic weighing (Bentzur, Kravitz, & Lockner 2008). In a similar study comparing underwater weighing to the BodPod, the body composition of 43 female college-aged participants was also found to be reliable (Maddolozzo, Cardinal & Snow 2002). The research literature supports the use of the BodPod as a valid and reliable method to determine body composition in collegiate female athletes.

Methodology

Participants

Study participants were intercollegiate female athletes ranging in age from 18 to 24 years. Athletes from a variety of sports were invited in order to compare findings from lean (sports where a lean appearance is correlated with success) and non-lean (sports where a lean body is not essential to success) sports; athletes choosing to participate in the present study included swimming (n=4), synchronized swimming (n=13), soccer (n=2), crew (n=15), softball (n=1), and ice hockey (n=5), therefore having 32 lean sport participants and 7 non-lean sport participants. With 50 women consenting to participate, complete data was collected from 40 participants. There was only one athlete from softball, which made for a bias in the statistics so that data was dropped leaving the study to evaluate 39 female athletes. Athletes were permitted to participate at any time of the year without documentation of specific workout volume though all subjects had not exercised the morning of the lab visit. All protocol methods were pre-approved by the Institutional Review Board at The Ohio State University prior to participation from subjects (2009H0038).

Questionnaires

Participants of this study were asked to complete the compendium of body image questionnaires on-line before the lab visit. Questionnaires included the AO and AE subscales of the Multi-Dimensional Body and Self-Relations Questionnaire (MBSRQ), Eating Disorder Examination (EDE) questionnaire (weight, shape, restraint and eating subscales), and Tendency to Diet Scale and the Contour Drawing Rating Scale difference (Silhouette model).

Questionnaire responses were exported from the survey tool database; subscales were calculated in Excel for merging with the other data for statistical analysis.

Laboratory measures of Resting Metabolic Rate and Body Composition

Resting metabolic rate was estimated using the ReeVue indirect calorimeter technology. The lab visits were early morning visits to attempt to capture the most resting metabolic rate. Again, subjects were instructed to refrain from eating, drinking, or exercising the morning of the lab visit. Once in the lab, subjects reclined in a chair for 10 minutes prior to estimating RMR. Subject data was entered into the ReeVue machine to translate the oxygen uptake of the athlete to the estimated RMR. The printed values from the RMR machine were then manually entered into Excel for collation with the other study variables.

The BodPod estimated percent body fat and fat free mass (FFM) of all participants. All subjects were measured according to manufacturer instructions to wear appropriate clothing (tight fitting clothing such as a bathing suit and hair cap), abstention from large meals or exercise prior to testing, and the machine properly calibrated daily in a temperature controlled room. Data from the BodPod was exported from the database and collated into a larger Excel data file for statistical evaluation.

The collated Excel data file was then imported into SAS (version 9.2, Cary NC) for statistical analysis. The correlations between the questionnaire data and the estimates of RMR and body fatness were evaluated using Proc Corr. The differences in questionnaire scores, RMR and body fatness between lean and non-lean sports were compared using t-tests to include appropriate evaluation of the homogeneity of variances. The comparison among sport groups for RMR, percent body fat and the body image markers were compared using the Proc GLM modeling due to unequal group sizes. The models by sport were finally evaluated using the Tukey post hoc testing option.

Results

Of the 50 consenting athletes, full data was analyzed for 39 participants. As anticipated, some participants enrolled but failed to complete all requirements for this study such as questionnaires or body measurement tests. The descriptive statistics for the final 39 participants is shown in Table 1.

Table 1. Descriptive statistics for sample of female collegiate athletes analyzed in this study.

	Mean	Minimum	Maximum	Std Dev
Height (in)	67.18	62	73	2.54
Weight (lbs)	150.18	110	195	20.36
Age	20.84	18.16	24.27	1.36

<u>Resting Metabolic Rate and Body Composition Measurements</u>

The mean resting metabolic rate of all female athletes was 1528.55 kcal (+/- 291.69 kcal) with values ranging from 979 kcal to 2102 kcal. The mean RMR for lean sport athletes was 1531 kcal and the mean RMR for non-lean sport athletes was 1517.5 kcal. When RMR was modeled by sport, a p-value of 0.0401 was noted, but no significant differences were seen between individual sports with Tukey's post hoc evaluations. This demonstrates that sport was a reasonable predictor of RMR in the regression equation, but that the differences were not large enough, given the standard deviations, to establish differences between particular sports. Table 2 contains the breakdown of RMR measurements by sport.

Table 2. RMR data in kcal by sport for sample of female collegiate athletes.

	Mean	Std Dev	Min	Max
Crew	1610.87	261.14	1008	1987
Ice Hockey	1532.2	369.45	1022	1944
Soccer	1663.5	173.24	1541	1786
Swim	1792.75	278.605	1498	2102
Synchro	1359.08	227.7	979	1786

Body composition was determined using the BodPod as described for all participants. The mean body fat percentage of all athletes was 26.79% +/- 4.47% with values ranging from 18.7% to 42.8%. Percent body fat for lean sports was 27%, while percent body fat was 25.8% for non-lean sports. No significant difference was noted between individual sports (p=0.5786), or between lean and non-lean athletes (p=0.4449). Table 3 shows the percent body fat by sport.

Table 3. Percent body fat values for collegiate female athletes by sport.

	Mean	Std Dev	Min	Max
Crew	28.18	6.13	18.7	42.8
Ice Hockey	24.92	4.38	18.8	29.9
Soccer	26.15	0.07	26.1	26.2
Swim	25.2	1.44	23.8	27
Synchro	26.26	2.88	21.3	30.5

Body Image Questionnaires

Subjects completed all four body image questionnaires using the on-line survey tool SelectSurvey. The range and means of all body image questionnaire scores are listed in Appendix B. Throughout all questionnaires, scores ranged from “very low” to “very high”, indicating participants’ attitudes regarding AO, AE, EDE-E, EDE-R, EDE-S, EDE-W, TD, and Silhouette differentials were quite varied across individual sports and sport groups.

The MBSRQ subscale scores are outlined in Table 4. AO scores ranged from 19 to 52 of a possible 60 points with a standard deviation of 6.8 amongst all participating athletes. The data reveals that there is no significant correlation between AO to a decreased RMR or body fatness in the pool of female athletes, with only a weak trend indicating non-lean athletes place more importance on their orientation (higher AO scores). A significant difference (Tukey test) was demonstrated; however, in AO scores between Swimming and Ice Hockey, indicating athletes in these sports place different importance on their appearances. Swimmers had a lower mean AO score of 28.5 (+/-8.3) while Ice Hockey athletes had a mean AO score of 43.2 (+/-5.8) out of a possible 60 points. Ironically, this suggests that ice hockey (non-lean sport) players place greater importance on their appearance than swimmers (lean sport). This relationship was unexpected due to the presumption that lean sports are more appearance oriented because their sport has an aesthetic component; athletes in non-lean sports, in comparison, do not have the same aesthetic pressure for their sport group.

AE scores for all subjects ranged from 15 to 35 out of a possible 35 points with a standard deviation of 4.4. A significant correlation between AE and percent body fat is demonstrated with a p-value of 0.0305, indicating as body satisfaction increases (a high AE scores), body fatness decreases. Alternatively, athletes with higher body fats are less satisfied with their bodies. No significant relationships of AE to RMR measurements (p= 0.8814), lean and non-athletes (p= 0.4813), or different sports were established (p= 0.8449).

Table 4. AO and AE statistical data of lean/non-lean sport groups and individual sports.

		AO	AE
Pearson correlations	RMR	r = -0.1791	r = 0.0247
		p = 0.2752	p = 0.8814
	% Fat	r =-0.0580	r = -0.3468
		p = 0.7259	p = 0.0305
T-tests Lean/Non-lean	Lean	36.16 (+/- 6.8)	24.88 (+/- 4.6)
	Non-lean	40.25 (+/- 6.10)	23.63 (+/- 3.7)
	p-value	0.1245	0.4813
Evaluation by sport	Swim	28.5 (+/- 8.3)	26.0 (+/- 8.4)
	Synchro	36.62 (+/- 6.6)	25.62 (+/- 4.0)
	Ice Hockey	43.2 (+/- 5.8)	24.0 (+/- 4.3)
	Soccer	34.0 (+/- 1.4)	24.5 (+/- 2.1)
	Crew	37.8 (+/- 5.5)	23.93 (+/- 4.2)
	p-value	0.0208	0.8449

The EDE subscale scores are listed in Table 5. The descriptive statistics for this group of subscales is detailed in data can be in Appendix B. Although no significant correlations were noted, a weak trend might be considered for both the EDE-E (p=0.1531) and the EDE-W (p=0.1070) with percent body fat. As well, the EDE-S and RMR values demonstrated a very weak trend (p=0.1385). The strength of these trends is low as witnessed by low Pearson values and slightly elevated p-values. No significant findings were identified in EDE scores between lean and non-lean athletes or between individual sports. This may be attributed to the large standard deviations seen in multiple sports and the wide range of minimum and maximums held by different sports (variability). Major correlations were seen amongst the subscales of the EDE and are detailed in Appendix C.

Table 5. EDE (E, R, S, and W) statistical data of lean/non-lean sport groups and individual sports.

		EDE-E	EDE-R	EDE-S	EDE-W
Pearson correlations	RMR	r = 0.1697	r = -0.0998	r = 0.1080	r = 0.2415
		p = 0.3017	p = 0.5456	p = 0.5127	p = 0.1385
	% Fat	r = 0.2332	r =0.0036	r =0.2621	r = -0.0154
		p = 0.1531	p = 0.9825	p = 0.1070	p = 0.9259
T-tests Lean/Non-lean	Lean	9.65 (+/- 9.7)	9 (+/- 7.25)	19.06 (+/- 16.1)	9.22 (+/- 19.8)
	Non-lean	14.5 (+/-11.6)	11.5 (+/- 5.9)	23.37 (+/- 23.1)	10.25 (+/- 16.5)
	p-value	0.2323	0.3737	0.5394	0.893
GLM	Swim	11.0 (+/- 7.5)	5.25 (+/- 4.1)	34.5 (+/- 29.5)	29.75 (+/- 47.1)
	Synchro	9.76 (+/- 13.2)	9.23 (+/- 8.7)	14.92 (+/- 14.6)	5.62 (+/- 9.5)
	Hockey	16.8 (+/-14.4)	10.4 (+/- 6.2)	30.2 (+/- 27.3)	16.0 (+/- 19.2)
	Soccer	8.0 (+/- 2.8)	10.0 (+/- 2.8)	8.0 (+/- 0)	0 (+/- 0)
	Crew	9.2 (+/- 6.8)	9.8 (+/- 6.6)	18.53 (+/- 11.1)	6.87 (+/- 13.3)
	p-value	0.6977	0.8245	0.1656	0.1745

Tendency to diet and Silhouette differential scores are found in Table 6. TD scores ranged from 26 to 52 out of a possible 60 points with a standard deviation of 5.7; Silhouette differentials ranged from 0 to 5. Both TD and Silhouette differentials were useful predictors (correlates) of percent body fat as evidenced by p-values of 0.0121 and 0.0004, respectively. Silhouette differential was marginally correlated to RMR where a trend is noted with a p-value of 0.0908. A t-test comparison of lean and non-lean groups revealed no differences in TD or Silhouette differential scores. Using generalized linear model (GLM) multivariate analysis, no significant differences were seen in individual sports in TD or Silhouette differential scores, indicating all sports have the same general dieting tendencies and similar body dissatisfaction attitudes as shown by Silhouette differential scores. Silhouette differential frequencies are listed in Table 7.

Table 6. TD and Silhouette differential statistical data of lean/non-lean sport groups and individual sports.

		TD	Sil Diff
Pearson correlations	RMR	r = 0.03933	r = 0.27452
		p = 0.8121	p = 0.0908
	% Fat	r = 0.39787	r = 0.54259
		p = 0.0121	p = 0.0004
T-tests Lean/Non-lean	Lean	40.38 (+/- 6.0)	1.66(+/- 1.3)
	Non-lean	42.88 (+/- 4.4)	1.43(+/- 0.53)
	p value	0.2733	0.4660
GLM	Swim	41.25 (+/- 4.6)	2.0 (+/- 1.6)
	Synchro	39.77 (+/- 6.9)	1.38 (+/- 1.4)
	Hockey	42.4 (+/- 4.2)	1.4 (+/- 0.5)
	Soccer	41.0 (+/- 4.2)	1.5 (+/- 0.7)
	Crew	40.67 (+/- 5.7)	1.8 (+/- 1.2)
	p-value	0.9389	0.857

Table 7. Silhouette differential frequencies of all participating athletes.

Sil diff	# of athletes
0	6
1	15
2	10
3	5
4	2
5	1
6	0

Answering the Research Questions

1) Do the Appearance Orientation and Appearance Evaluation domains of the Multidimensional Body Self-Relations Questionnaire correlate with a decreased resting metabolic rate or body fatness, and is there a significant difference in AO or AE for the lean and non-athlete female athlete groups, or by sport?

The MBSRQ sub scales, AO and AE, showed some correlations to the examined variables. AO, although not significantly different, exhibited a week trend with a p-value of 0.1245 between lean and non-lean athletes, with non-lean athletes placing more importance on their appearance. This was an unexpected finding due to the nature of lean and non-lean sport groups and the different aesthetic pressures between groups. AO was statistically significant between individual sports with a p-value of 0.0208, indicating AO scores can be predicted based on the sport an athlete plays. AE showed a significant correlation to body fatness, with higher AE scores correlating to lower body fatness (p-value of 0.0305). No significant findings were established between AE between lean and non-lean sports or between individual sports.

2) Do the subscales of the Eating Disorder Examination (concern for Weight, Shape, Eating, and Restraint) correlate with a decreased resting metabolic rate or body fatness, and is there a significant difference between lean and non-lean female athlete groups, or by sport?

No significant findings were exhibited between the EDE-Q subscales of eating, restraint, shape and weight concern to body fatness, RMR, lean and non-athlete differences or differences between individual sports. It should be noted that many significant correlations were seen between body image questionnaires (Appendix C).

3) Does Tendency to Diet score correlate with a decreased resting metabolic rate or body fatness, and is there a significant difference in the tendency to diet score for the lean and non-athlete female athlete groups, or by sport?

The Tendency to Diet score (TD) was significantly correlated with body fatness with a p-value of 0.0121, indicating that a higher TD score is correlated to higher body fatness. This finding is consistent with research the Deutz et al study that states persons who practice dieting habits have increased body fatness (Deutz et al 2000). TD was not a significant predictor of RMR, lean or non-lean sports, or individual sport differences.

4) Do the differences between perceived and ideal Silhouette drawings*, correlate with a decreased resting metabolic rate or body fatness, and is there a significant difference between lean and non-lean female athlete groups, or by sport?*

Silhouette drawing differentials were the most statistically significant body image questionnaire predictor of RMR and body fatness examined in this study. Silhouette differentials exhibited a p-value of 0.0908 when correlated to RMR and a p-value of 0.0004 when correlated to body fatness. There were no significant differences found between lean and non-lean athletes or between individual sports.

Discussion and Conclusion

Although this study only analyzed data from 39 collegiate female athletes, it provides some interesting information about the complex relationship of body image to body measurements such as RMR and percentage body fat in Division I female athletes. A wide range of tools and scores were collected from this group of athletes, reflecting the different attitudes held but the potential nature of these attitudes among athletes in each sport. The data was not able to support conclusive evidence regarding the differences in body image attitudes and habits between lean and non-lean sports, so this remains a controversial topic that deserves further consideration in future studies.

The body image questionnaires as a whole did not show any statistical differences in attitudes between lean and non-lean sport groups or by sport. The MBSRQ sub scales AO and AE failed to provide any clear evidence that lean and non-lean athletes have different body image beliefs, values, or practices which goes against the hypothesis that lean athletes place greater importance on maintaining a lean frame than non-athletes. The opposite holds true for the comparison of AO between ice hockey athletes and swimmers, where ice hockey players had greater AO scores. This suggests that ice hockey athletes, a non-lean sport, may place greater importance on their appearance than the lean sport of swimming. This is a surprising finding because ice hockey players do not have the sport-associated aesthetic pressures that lean sport athletes might experience, suggesting there may be another factor contributing to the increased orientation importance. This ironic finding likely reflects the idea that body image is different amongst individuals (Hubley and Rusticus 2006), and it may be a team culture trend. The EDE-Q sub scales did not provide any significant findings either in terms of lean and non-athlete differences. There were major correlations seen between these sub scales (eating, shape, restraint, and weight). Finally, TD and Silhouette differentials also did not support differences between lean/non-lean athletes. Researchers should continue to search for discrete differences in body image scores between groups and by sport in order to identify which athletes may be at a greater risk for disorder eating or exercising tendencies, though it seems the evidence is mounting for the statement that there are no differences between lean and non-lean sports. This research supports the notion that all sports might be at similar risks for eating disorders, and that the risk is likely individual.

Notable correlations were seen between RMR measurements and body fatness in a number of the body image questionnaire sub sections. The AE sub scale was highly correlated to percent body fat, suggesting that based on an athletes' satisfaction or dissatisfaction with her body, body fatness can be predicted. Although Garner's hypothesis indicates up to 60% of body image is determined by weight, percent body fat (a different body measurement) was found to be a significant contributor to body evaluation, suggesting multiple components of body measurements are considered by athletes in body evaluation; this may be different than the general population and deserves further exploration. The TD scale was also significantly correlated with body fatness in athletes of this study. Athletes with greater dieting tendencies (energy restriction or increased energy expenditure) exhibit higher levels of body fatness, thus supporting Deutz's conclusion from his 2000 study. It is important to note that both this study and the Deutz study were cross-sectional in nature and it is not possible to determine if dieting tendencies are the response to or cause of the higher body fatness.

Finally, Silhouette differential scores were interestingly significant in not only RMR correlations but body fatness as well. Attention should be drawn to the data in that none of the athletes indicated wanting a silhouette figure bigger than their current (or "real") body, supporting Garner's notion that 89% of women desire to lose weight. There may be some inherent reporting flaws with silhouette drawings, however. These silhouette differences continue to be robustly correlated to markers of body image, fatness and RMR. We suggest they are a less threatening surrogate marker for how one treats her body. Asking athletes about the presence of an eating disorder or how they feel about their body has the potential to get less than honest data while the silhouette method might seem less personal or threatening. Regardless, silhouette models continue to be a useful indicator of body image and show significant correlation to body fatness and RMR.

Because athletes were not required to be in season or out of season to participate, some variation in RMR and percent body fatness values can be expected. Acute bouts of exercise can increase RMR values (Binzen et al 2001); it is possible that in-season athletes showed greater RMR values than out of season athletes and may have contributed to the large standard deviation numbers, making significance difficult to identify. Slight differences in body fat percentage may have also been prevalent for in-season or out of season athletes due to the differences in exercise schedules of in-season athletes (such as mandatory practice or workouts and competitions), compared to the potential decreased time commitment and increased diet leniency experienced by some out of season athletes. The control for in or out of season would limit this potential bias. It is difficult to know if teams are required to work out more or less intensely at different points of competition and the likely situation is not predictable. This limitation could be improved in future studies in order to have a more homogenous pool of subjects.

It is interesting to note the distribution of lean and non-lean athletes selecting to participate in this study, and consider that these unequal numbers may not be coincidental. This study was comprised of 32 lean athletes with only 7 non-lean athletes for comparison; although this may seem to reflect poor recruiting techniques or that there was limited exposure of this study to athletes of other sports, it is possible it is rather a reflection of the types of athletes that may be inclined to participate in a study involving body measurements like RMR and body fat percentage. Participation in this study examining RMR and body fat required a time commitment from each athlete, but each athlete benefitted from finding out her values from each measurement taken. It is likely that only athletes who are invested in discovering these body measurements would consent and prioritize time to participate. This may explain the unequal distribution of lean to non-lean athletes, indicating lean athletes are more interested and invested in their bodies. The athletes from the non-lean sports who chose to participate may be more vested in their RMR and body than athletes of the same sports who chose not to participate. Athletes from women’s basketball and gymnastics were also invited to participate in this study, but no athletes decided to participate. Regardless of the reason for an unequal number of lean and non-lean athletes, this distribution could be evened out in future studies in order to see stronger numerical support for the comparison between sport groups.

This study examined the complex and interesting relationship between body image, RMR and body fatness of lean and non-lean collegiate female athletes because body image attitudes, beliefs and habits can be prime indicators of altered RMR or body fatness levels. Future studies should focus on identifying specific differences between questionnaires and their relationships to body measurements. Identification of risky behaviors could be a helpful clinical tool to monitor at-risk athletes; steps could then be taken to ensure these athletes receive proper nutrition education, carry out healthier eating and exercise practices and, ultimately, obtain higher RMR values, decreased body fatness, and higher appearance evaluation scores.

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Appendices

Appendix A. Distribution of participants by lean and non-lean sport groups and individual sports.

Lean Sports	**# of Athletes**	**Non-Lean Sports**	**# of Athletes**
Crew	15	Ice Hockey	5
Swimming	4	Soccer	2
Synchronized Swimming	13		
Total	32	Total	7

Appendix B. Body image questionnaires statistical data.

	Mean	Minimum	Maximum	Std Dev
AO	36.98	19	52	6.81
AE	24.63	15	35	4.41
EDE-R	9.5	0	30	7.01
EDE-E	10.63	0	46	10.16
EDE-S	19.93	0	70	17.47
EDE-W	9.43	0	99	19.01
DH	40.88	26	52	5.71

Appendix C. EDE-Q statistical correlations to other body image questionnaires. Pearson correlation values are listed above corresponding p-values.

	EDE-E	EDE-R	EDE-S	EDE-W	AO	AE	Sil Diff	TD
EDE-E	1	0.5182	0.4835	0.491	0.0751	-0.2451	0.3328	0.6362
		0.0007	0.0018	0.0015	0.6496	0.1327	0.0384	0.0001
EDE-R	0.5182	1	0.2727	0.1515	0.2642	-0.3886	0.3186	0.6234
	0.0007		0.093	0.3571	0.1041	0.0145	0.0482	0.0001
EDE-S	0.4835	0.2727	1	0.3511	0.0712	-0.5312	0.4622	0.5171
	0.0018	0.093		0.0284	0.6666	0.0008	0.0031	0.0007
EDE-W	0.491	0.1515	0.3511	1	-0.2967	-0.0037	0.0808	0.3236
	0.0015	0.3571	0.0284		0.0666	0.9823	0.6245	0.0445
AO	0.0751	0.2642	0.0712	-0.2967	1	-0.3521	0.2062	0.1452
	0.6496	0.1041	0.6666	0.0666		0.0279	0.2079	0.3778
AE	-0.2451	-0.3886	-0.5312	-0.0037	-0.3521	1	-0.6326	-0.5815
	0.1327	0.0145	0.0008	0.9823	0.0279		0.0001	0.0001
Sil Diff	0.3328	0.3186	0.4622	0.0808	0.2062	-0.6326	1	0.582
	0.0384	0.0482	0.0031	0.6245	0.2079	0.0001		0.0001
TD	0.6362	0.6234	0.3236	0.3236	0.1452	-0.5815	0.582	1
	0.0001	0.0001	0.0445	0.0445	0.3778	0.0001	0.0001	